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(54) OPTICAL WAVELENGTH MULTIPLEX TRANSMISSION SYSTEM

(57)Abstract:

PURPOSE: To suppress crosstalk between signal lights and to make a wavelength interval narrow by selecting a wavelength interval between output lights of an optical transmitter to be smaller than a minimum wavelength interval obtained by an optical branching means and making polarized directions of output lights of adjacent wavelengths nearly orthogonal to each other.

CONSTITUTION: Two signal lights λi, $\lambda i+1$ set at a smaller wavelength interval than a minimum permissible wavelength interval $\Delta\lambda 0$ decided by an optical branch means 5 are nearly subject to orthogonal control by polarized light control means 2−i, 2−(i+1) and the resulting signals are sent. When the one signal light λi in both signals is received by an optical receiver 7−i, since the wavelength interval $(\Delta\lambda i+1, i)$ of both signal lights is smaller than the minimum permissible wavelength interval $\Delta\lambda 0$ of the means 5, part of the signal light $\lambda i+1$ is inputted to a polarized light separate means 6−i from the means 5 together with a receiver side signal light λi.

Since the signal lights λi, $\lambda i+1$ nearly have an orthogonal relation and only the component light in parallel with the signal light λi received by the means 6−i is extracted separately, the signal light $\lambda i+1$ is eliminated. Thus, only the signal light λi reaches an optical receiver 7−i to suppress crosstalk.
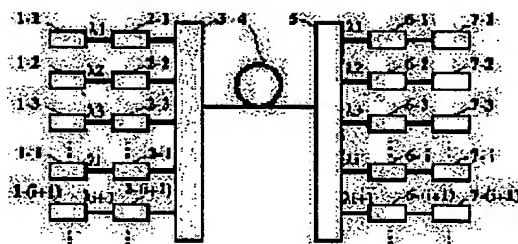
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CLAIMS

[Claim(s)]
[Claim 1] At least two or more optical transmitters which transmit a signal using the subcarrier from which wavelength differs mutually, At least two or more polarization control means which control and output the polarization direction of each output light of the above-mentioned optical transmitter, An optical multiplexing means to multiplex the output light of the above-mentioned polarization control means, and the optical transmission line which transmits the output light of the above-mentioned optical multiplexing means, An optical spectral separation means to separate spectrally the signal light transmitted by the above-mentioned transmission line in a wavelength field, In the light wave length multiplex transmission system equipped with at least one or more polarization separation means to output only the polarization component of the one direction of the spectral separation output light of the above-mentioned light spectral separation means, and at least one or more optical receivers which receive the output light of the above-mentioned polarization separation means In said optical transmitter, at least wavelength spacing between two optical transmitters of a lot It sets up smaller than the minimum permission wavelength spacing required to obtain an oppression ratio required to disregard the effect of crosstalk in case a lightwave signal is received in said optical spectral separation means. And the light wave length multiplex transmission system characterized by carrying out the abbreviation rectangular cross of the polarization direction of the output light of two optical transmitters of those groups by said polarization control means.
[Claim 2] The light wave length multiplex transmission system according to claim 1 characterized by having a negative feedback means to control said polarization separation means to make power of the output light of said polarization separation means into max.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the light wave length multiplex transmission system which multiplexes and transmits the lightwave signal of two or more wavelength.
[0002]
[Description of the Prior Art] Drawing 9 is the block diagram of general light wave length multiplex transmission. It is multiplexed by optical multiplexing means (3), such as an optical coupler, and the lightwave signal (lambda1, lambda2, lambda3, —) which was outputted from the optical transmitter (1-1, 1-2, 1-3, —) and with which luminescence wavelength differs, respectively forms light wave length multiple-signal light. After light wave length multiple-signal light transmits an optical transmission line (4), it is separated spectrally for every wavelength by the optical spectral separation means (5) in a wavelength field, and it is inputted into an optical receiver (7-1, 7-2, 7-3, —).
[0003] In such a light wave length multiplex transmission system, in case a certain signal light is received, it is necessary to remove all other signal light of the signal light which receives with the optical spectral separation means (5) in a wavelength field. however, when wavelength spacing of the signal light of the signal to receive and the wavelength which adjoins the signal light which receives is too small With an optical spectral separation means (5), since signal light of the adjoining wavelength cannot be removed, a part of power of the signal light of the wavelength which adjoins input-signal light is inputted into an optical receiver (7-1, 7-2, 7-3, —), and it causes crosstalk between signals in input-signal light and coincidence.
[0004] In order to prevent crosstalk between such signals, generally, with the wavelength multiplex transmission system, wavelength spacing between the signal light which each optical transmitter outputs was fully extended, and although the effect of crosstalk can be disregarded in case signal light is received, sufficient oppression ratio has been obtained in the optical spectral separation means. About such technique, about the case where the filter of a Fabry Perot resonator mold is used for an optical spectral separation means, for example IEEE besides an alder bullet, the 8th volume of journal-on SEREKUTEDDO Air RIASU Inn Communications, No. 6, the 1095 – 1107th page, 1990 () [P.A.Humblet] It argues in detail et al., IEEE Journal on Selected Areas in Communcations, Vol.8, No.6, pp.1095-1107, and 1990.
[0005]
[Problem(s) to be Solved by the Invention] However, when it was not able to narrow, but multiplex [of the signal light] was carried out to high density and transmission capacity was large-capacity-ized rather than the minimum permission wavelength spacing required to obtain oppression ratio sufficient by the above-mentioned conventional approach to disregard the effect of crosstalk in case signal light is received for wavelength spacing between signal light in said optical spectral separation means, there was a fault acting as a failure.
[0006] The purpose of this invention is to offer the light wave length multiplex transmission system which said trouble is solved, and the effect of the crosstalk in a receiver is controlled, and can make wavelength spacing small.
[0007]

[Means for Solving the Problem] Drawing 1 is the basic block diagram of invention of the 1st of this application. The configuration which invention of the 1st of this application offers in order to attain the above-mentioned purpose At least two or more optical transmitters which transmit a signal using the subcarrier from which wavelength (lambda1, lambda2, lambda3, --) differs mutually (1-1, 1-2, 1-3, --), At least two or more polarization control means which control and output the polarization direction of each output light of the optical transmitter (2-1, 2-2, 2-3, --), The optical transmission line which transmits the output light of an optical multiplexing means (3) to multiplex the output light of the polarization control means, and its optical multiplexing means (4), An optical spectral separation means to separate spectrally the lightwave signal transmitted by the transmission line in a wavelength field (5), At least one or more polarization separation means to output only the polarization component of the one direction of the spectral separation output light of the optical spectral separation means (6-1, 6-2, 6-3, --), In the light wave length multiplex transmission system equipped with the optical receiver (7-1, 7-2, 7-3, --) which receives the output light of the polarization separation means In said optical transmitter, at least wavelength spacing (deltalambdai+1 and i=lambda i+1-lambdai) between the output light (lambdai, lambdai+1) of two optical transmitters of a lot It sets up smaller than the minimum permission wavelength spacing (deltalambda0) required to obtain an oppression ratio required to disregard the effect of crosstalk in case a lightwave signal is received in said optical spectral separation means (deltalambdai+1, i<delta lambda 0). And it is characterized by carrying out the abbreviation rectangular cross of the polarization direction of the output light (lambdai, lambdai+1) of two optical transmitters of those groups by said polarization control means (2-i and 2- (i+1)).

[0008] Moreover, drawing 3 is the basic block diagram of invention of the 2nd of this application. The configuration which invention of the 2nd of this application offers in order to attain the above-mentioned purpose is characterized by to have the negative feedback means (8-1, 8-2, 8-3, --) which controls the polarization separation means to make power of the output light of said polarization separation means (6-1, 6-2, 6-3, --) into max in addition to the configuration which invention of the 1st of said this application offers.

[0009]

[Function] Drawing 2 is the principle Fig. of invention of the 1st of this application. According to invention of the 1st of this application, to the minimum permission wavelength spacing (deltalambda0) which an optical spectral separation means (5) defines, two signal light (lambdai, lambdai+1) set up at intervals of small wavelength (deltalambdai+1, i) is transmitted, after polarization control is carried out so that the polarization direction may carry out an abbreviation rectangular cross by the polarization control means (2-i and 2- (i+1)). The case where an optical receiver (7-i) receives one signal light (lambdai) among these two signal light (lambdai, lambdai+1) is considered here, for example. Since wavelength spacing (deltalambdai+1, i) of two signal light is smaller than the minimum permission wavelength spacing (deltalambda0) of an optical spectral separation means (5), a part of another signal light (lambdai+1) is inputted into a polarization separation means (6-i) from an optical spectral separation means (5) with the signal light (lambdai) of the direction which receives. However, since the polarization direction of these two signal light (lambdai, lambdai+1) is in abbreviation orthogonality relation, another signal light (lambdai+1) is removed by separating and taking out only the light of a component parallel to the signal light (lambdai) of the direction which receives with a polarization separation means (6-i). Therefore, only the signal light (lambdai) of the direction which receives reaches an optical receiver (7-i), and becomes receivable without the effect of crosstalk.

[0010] Moreover, if the case where an optical receiver (7-i) receives signal light (lambdai), for example following on an operation of invention of the 1st of above-mentioned this application is considered according to invention of the 2nd of this application Since light other than signal light (lambdai) is decreasing the signal light inputted into a polarization separation means (6-i) with the optical spectral separation means (5) By controlling to make output light of a polarization separation means (6-i) into max, only a component with the parallel polarization direction is automatically divided into signal light (lambdai), and an operation of invention of the 1st of above-mentioned this application is brought about.

[0011]
[Example] The example of invention of the 1st of this application is explained using drawing 1 . an optical transmitter (1-1, 1-2, 1-3, ---) -- for example, it is constituted by the laser diode by which direct modulation was carried out or a laser diode, the external modulator, etc., and the signal light (lambda1, lambda2, lambda3, ---) modulated independently, respectively is outputted. The subscript of the wavelength of signal light shall be assigned from a short wavelength side here (lambda1<lambda2<lambda3<---). each signal light should pass a polarization adjustment means (2-1, 2-2, 2-3, ---) -- it is multiplexed with an optical multiplexing means (3), and a light wave length multiple signal is formed. A polarization adjustment means (2-1, 2-2, 2-3, ---) consists of a quarter-wave length plate and 1/2 wavelength plate. Have the work which changes the light of the polarization of arbitration into the linearly polarized wave of the direction of arbitration, and the polarization direction of the wavelength group (lambda 1, lambda3 ---) of an odd number is [a subscript] parallel. It is adjusted so that the polarization direction of the wavelength group (lambda 2, lambda4 ---) of an even number may become parallel, and it is adjusted so that the polarization direction may intersect perpendicularly by those wavelength between groups. Moreover, an optical multiplexing means is constituted by polarization composition machines, such as a polarization beam splitter, a wavelength multiplexing coupler, or the star coupler. A light wave length multiple signal inputs an optical transmission line (4) (for example, optical fiber) into an optical spectral separation means (5) after transmission. An optical spectral separation means (5) is constituted by for example, a wavelength multiplexing coupler, a diffraction grating, or prism, for every wavelength, divides the inputted light wave length multiple signal separately, and outputs it. (A crosstalk component is explained later.)
Or a configuration as shows an optical spectral separation means (5) to drawing 4 is also considered. The signal light (lambda1, lambda2, lambda3, ---) transmitted in drawing 4 is distributed to an optical filter (12-1, 12-2, 12-3, ---) by the star coupler (11). An optical filter (12-1, 12-2, 12-3, ---) is an optical band pass filter of a dielectric multilayers mold or Fabry-Perot, and has a wavelength selection-transparency property centering on a certain main wavelength. Or it is also possible to substitute the component which has a steep gain property near a certain specific wavelength. For example, as for the signal light (lambda1, lambda2, lambda3, ---) inputted into the optical filter (12-1), only signal light (lambda 1) is outputted. (A crosstalk component is explained later.)
Or a configuration as shows a spectral separation means (5) to drawing 5 is also considered. The signal light (lambda1, lambda2, lambda3, ---) transmitted in drawing 5 is distributed to a main wavelength adjustable optical filter (13-1, 13-2, 13-3, ---) by the star coupler (11). For example, when the signal light (lambda1, lambda2, lambda3, ---) inputted into the main wavelength adjustable optical filter (13-1) carries out adjustable [of the main wavelength], only the signal light of arbitration is outputted. (A crosstalk component is explained later.)
The signal light (lambda1, lambda2, lambda3, ---) separately outputted for every wavelength from this optical spectral separation means (5) is inputted into a polarization separation means (6-1, 6-2, 6-3, ---), respectively. Each polarization separation means consists of for example, a quarter-wave length plate, 1/2 wavelength plate, and a polarization beam splitter, and has the work which makes only one polarization component of the arbitration of the cross polarization light of arbitration penetrate. The output light of each polarization separation means is inputted into an optical receiver (7-1, 7-2, 7-3, ---) (for example, photodiode), and is received.
[0012] The signal light to overhear was not taken into consideration in the explanation so far. In consideration of the crosstalk at the time of spectral separation, it explains from this. When an optical spectral separation means (5) performs spectral separation, the magnitude of attenuation in the relative wavelength (deltalambda0) from the main wavelength of the light separated spectrally is set to FdB. If the oppression ratio of the crosstalk permitted on the occasion of reception is set to FdB, the minimum permission wavelength spacing in this optical spectral separation means (5) will be set to (deltalambda0). Moreover, fdB, then 0<f<F are filled in the magnitude of attenuation in relative wavelength spacing (deltalambda0/2). Furthermore, since the magnitude of attenuation of a polarization separation means generally fulfills the conditions of a permission crosstalk oppression ratio when the magnitude of attenuation in case each

polarization separation means (6-1, 6-2, 6-3, —) separates one polarization component of direct polarization light is set to PdB, it becomes F<P.

[0013] Here, it transmits by setting signal light (lambda1, lambda2, lambda3, —) as wavelength spacing, such as (deltalambda0 / 2). For example, in case an optical receiver (7-3) receives signal light (lambda 3), a polarization separation means (6-3) is set up so that only a component parallel to (lambda 3) may be taken out. this time — signal light (lambda1, lambda2, lambda4, and lambda5) — signal light (lambda 3) — receiving — respectively (deltalambda0) — (deltalambda0 / 2) — since it has wavelength spacing, and (deltalambda0/2) (deltalambda0) inputs into a polarization separation means (6-3), after decreasing only FdBfdB, and fdB and FdB with an optical spectral separation means (5), respectively. further — the polarization direction of signal light (lambda1, lambda2, lambda4, and lambda5) — the polarization direction of signal light (lambda 3) — receiving — respectively — parallel and a perpendicular — since it is perpendicular and parallel, only 0dB, PdB, PdB, and 0dB are decreased with a polarization separation means (6-3), respectively. Therefore, in the input of an optical receiver (7-3), signal light (lambda 3) obtains the oppression ratio of FdB, f+PdB, f+PdB, and FdB to signal light (lambda1, lambda2, lambda4, and lambda5), respectively. Moreover, since the amount of oppression of the other signal light is more than FdB at least, it satisfies more than the amount FdB of crosstalk oppression permitted, and serves as ability ready for receiving in signal light (lambda 3).

[0014] The wavelength arrangement in the above-mentioned example is set up in the following procedures. In the minimum case, since the amount [in / in a subscript / the between groups one of odd wavelength groups (lambda 1, lambda3 —) or even wavelength groups (lambda 2, lambda4 —)] of crosstalk is determined by the oppression ratio of an optical spectral separation means, the between-groups wavelength spacing becomes equal to the minimum permission wavelength spacing (deltalambda0) of an optical spectral separation means. wavelength spacing (deltalambda) of the signal which adjoins on the other hand since the amount of crosstalk of a signal light (for example, lambda2 and lambda3) different between groups is determined by the oppression ratio in a polarization separation means — 0 — < (deltalambda) — < (deltalambda0) — it can set up freely in between. However, it is more desirable to obtain a certain amount of oppression with the optical spectral separation means, if control of a polarization separation means is taken into consideration (the direction which enlarges the optical power difference of the signal to receive and the signal which is not received). it is based also on the point and practical — etc. — considering the case of wavelength spacing, each wavelength spacing (deltalambda) of an adjoining signal light will be set as (deltalambda0 / 2) of the one half of between-groups wavelength spacing (deltalambda0) so that wavelength spacing of a comrade between groups may be first set as (deltalambda0) and then it may be arranged at intervals of wavelength [light / all / signal] in the minimum case.

[0015] Since wavelength spacing is required also of min to perform same transmission by the conventional wavelength multiplex transmission system (deltalambda0), wavelength spacing is reduced by half by this invention.

[0016] Moreover, in implementation of invention of the 1st of this application, there is no need that an optical transmitter (1-1, 1-2, 1-3, —) and an optical receiver (7-1, 7-2, 7-3, —) are the same numbers, and the example from which those numbers differ is also considered. The extreme example is the case where the number of receivers as shown in drawing 6 is one. In this example, spectral separation is performed with a wavelength adjustable optical filter (13-1), and it becomes ability ready for receiving about the signal light of arbitration with one receiver (7-1) among all signal light (lambda1, lambda2, lambda3, —). One application of this example is shown in drawing 7 . This application prepares n the sending stations (51) and receiving stations (52) in drawing 6 , and connects them by the nxn star coupler (53).

[0017] Moreover, one example of invention of the 2nd of this application is explained using drawing 3 . Among drawing, the thing of the same reference number as the 1st example expresses the same component, and has the same property. Moreover, drawing 8 is the configuration of the control circuit of the polarization separation means (6-3) in this example. Since the basic configuration of each polarization separation means (6-1, 6-2, 6-3, —) is the

same, the following explains in the control circuit of a polarization separation means (6-3). A polarization separation means (6-3) is classified into the polarization control section (9-3) which consists of for example, a quarter-wave length plate and 1/2 wavelength plate, and the polarization separation section (10-3) which consists of for example, polarization beam splitters, is the whole and serves to make only one polarization component of the arbitration of the cross polarization light of arbitration penetrate. A negative feedback means (8-3) inputs the information about the power of the output light from a polarization separation means (6-3) from an optical receiver (7-3) in the form of an average current and electrical signals, such as instantaneous-carrying-current amplitude value, the polarization direction is rotated by the polarization control section (9-3) based on the electrical signal, and a negative feedback control is performed so that the power of the output light from the polarization separation section (10-3) may serve as maximum.

[0018] The case where an optical receiver (7-3) receives signal light (lambda 3) like one example of invention of the 1st of above-mentioned this application is considered here. As for signal light (lambda1, lambda2, lambda4, and lambda5) other than signal light (lambda 3), the light inputted into a polarization separation means (6-3) is decreasing only FdB, fdB, and fdB and FdB with the optical spectral separation means (5), respectively. this time -- the polarization direction of signal light (lambda1, lambda2, lambda4, and lambda5) -- the polarization direction of signal light (lambda 3) -- receiving -- respectively -- parallel and a perpendicular -- since it is perpendicular and parallel, in the polarization direction where the input light of a polarization separation means (6-3) is parallel to signal light (lambda 3), optical power serves as max. Since a negative feedback means (8-3) controls the polarization separation section (9-3) to make average power of the output light of a polarization separation means (6-3) into max, only a component with the parallel polarization direction is automatically outputted to signal light (lambda 3) from the polarization separation section (10-3). At this time, only 0dB, PdB, PdB, and 0dB (lambda1, lambda2, lambda4, and lambda5) of signal light are decreased by the polarization separation section (10-3), respectively. Therefore, in the input of an optical receiver (7-3), signal light (lambda 3) obtains the oppression ratio of FdB, f+PdB, f+PdB, and FdB to signal light (lambda1, lambda2, lambda4, and lambda5), respectively. Moreover, since the amount of oppression of the other signal light is more than FdB at least, it satisfies the amount FdB of crosstalk oppression permitted, and serves as ability ready for receiving in signal light (lambda 3).

[0019] Various deformation gestalten of a series of examples described above in operation of this invention are possible. For example, although the rotation phase plate was used as a means to control polarization, in a series of above-mentioned examples, the same effectiveness is acquired also with a rotation mold fiber coil or a rotation mold fiber crank, and the polarization control by Faraday rotator, a pressurization fiber, an electro-optics crystal, etc. may be used. Moreover, as a polarization composition machine or a polarization eliminator, the polarization eliminator by the prism using a birefringence and the polarization eliminator which fused the polarization maintenance fiber may be used also except a polarization beam splitter. Moreover, the optical direct junction transmission line which consists of an optical fiber and an optical amplifier as an optical transmission line may be used, and the wavelength dependency of the gain of an optical amplifier is large, and it is effective especially when the transmission band of a transmission line is restricted.

[0020]
[Effect of the Invention] Since it becomes possible to narrow wavelength spacing, with crosstalk controlled according to this invention as explained above, it is effective, also when carrying out multiplex [of the signal] to high density and carrying out light wave length multiplex transmission effectively [when carrying out light wave length multiplex transmission] using the narrow transmission line of a transmission band.
[0021]

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the light wave length multiplex transmission
system which multiplexes and transmits the lightwave signal of two or more wavelength.

[Translation done.]

* NOTICES *

PRIOR ART

[Description of the Prior Art] Drawing 9 is the block diagram of general light wave length multiplex transmission. It is multiplexed by optical multiplexing means (3), such as an optical coupler, and the lightwave signal (lambda1, lambda2, lambda3, ——) which was outputted from the optical transmitter (1-1, 1-2, 1-3, ——) and with which luminescence wavelength differs, respectively forms light wave length multiple-signal light. After light wave length multiple-signal light transmits an optical transmission line (4), it is separated spectrally for every wavelength by the optical spectral separation means (5) in a wavelength field, and it is inputted into an optical receiver (7-1, 7-2, 7-3, ——).
[0003] In such a light wave length multiplex transmission system, in case a certain signal light is received, it is necessary to remove all other signal light of the signal light which receives with the optical spectral separation means (5) in a wavelength field. however, when wavelength spacing of the signal light of the signal to receive and the wavelength which adjoins the signal light which receives is too small With an optical spectral separation means (5), since signal light of the adjoining wavelength cannot be removed, a part of power of the signal light of the wavelength which adjoins input-signal light is inputted into an optical receiver (7-1, 7-2, 7-3, ——), and it causes crosstalk between signals in input-signal light and coincidence.
[0004] In order to prevent crosstalk between such signals, generally, with the wavelength multiplex transmission system, wavelength spacing between the signal light which each optical transmitter outputs was fully extended, and although the effect of crosstalk can be disregarded in case signal light is received, sufficient oppression ratio has been obtained in the optical spectral separation means. About such technique, about the case where the filter of a Fabry Perot resonator mold is used for an optical spectral separation means, for example IEEE besides an alder bullet, the 8th volume of journal-on SEREKUTEDDO Air RIASU Inn Communications, No. 6, the 1095 – 1107th page, 1990 () [P.A.Humblet] It argues in detail et al., IEEE Journal on Selected Areas in Commuincations, Vol.8, No.6, pp.1095-1107, and 1990.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Since it becomes possible to narrow wavelength spacing, with crosstalk controlled according to this invention as explained above, it is effective, also when carrying out multiplex [of the signal] to high density and carrying out light wave length multiplex transmission effectively [when carrying out light wave length multiplex transmission] using the narrow transmission line of a transmission band.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, when it was not able to narrow, but multiplex [of the signal light] was carried out to high density and transmission capacity was large-capacity-ized rather than the minimum permission wavelength spacing required to obtain oppression ratio sufficient by the above-mentioned conventional approach to disregard the effect of crosstalk in case signal light is received for wavelength spacing between signal light in said optical spectral separation means, there was a fault acting as a failure.
[0006] The purpose of this invention is to offer the light wave length multiplex transmission system which said trouble is solved, and the effect of the crosstalk in a receiver is controlled, and can make wavelength spacing small.

[Translation done.]

MEANS

[Means for Solving the Problem] <u>Drawing 1</u> is the basic block diagram of invention of the 1st of this application. The configuration which invention of the 1st of this application offers in order to attain the above-mentioned purpose At least two or more optical transmitters which transmit a signal using the subcarrier from which wavelength (lambda1, lambda2, lambda3, —) differs mutually (1-1, 1-2, 1-3, —), At least two or more polarization control means which control and output the polarization direction of each output light of the optical transmitter (2-1, 2-2, 2-3, —), The optical transmission line which transmits the output light of an optical multiplexing means (3) to multiplex the output light of the polarization control means, and its optical multiplexing means (4), An optical spectral separation means to separate spectrally the lightwave signal transmitted by the transmission line in a wavelength field (5), At least one or more polarization separation means to output only the polarization component of the one direction of the spectral separation output light of the optical spectral separation means (6-1, 6-2, 6-3, —), In the light wave length multiplex transmission system equipped with the optical receiver (7-1, 7-2, 7-3, —) which receives the output light of the polarization separation means In said optical transmitter, at least wavelength spacing (deltalambdai+1 and i=lambda i+1-lambdai) between the output light (lambdai, lambdai+1) of two optical transmitters of a lot It sets up smaller than the minimum permission wavelength spacing (deltalambda0) required to obtain an oppression ratio required to disregard the effect of crosstalk in case a lightwave signal is received in said optical spectral separation means (deltalambdai+1, i<delta lambda 0). And it is characterized by carrying out the abbreviation rectangular cross of the polarization direction of the output light (lambdai, lambdai+1) of two optical transmitters of those groups by said polarization control means (2-i and 2- (i+1)).
[0008] Moreover, <u>drawing 3</u> is the basic block diagram of invention of the 2nd of this application. The configuration which invention of the 2nd of this application offers in order to attain the above-mentioned purpose is characterized by to have the negative feedback means (8-1, 8-2, 8-3, —) which controls the polarization separation means to make power of the output light of said polarization separation means (6-1, 6-2, 6-3, —) into max in addition to the configuration which invention of the 1st of said this application offers.

[Translation done.]

OPERATION

[Function] Drawing 2 is the principle Fig. of invention of the 1st of this application. According to invention of the 1st of this application, to the minimum permission wavelength spacing (deltalambda0) which an optical spectral separation means (5) defines, two signal light (lambdai, lambdai+1) set up at intervals of small wavelength (deltalambdai+1, i) is transmitted, after polarization control is carried out so that the polarization direction may carry out an abbreviation rectangular cross by the polarization control means (2-i and 2- (i+1)). The case where an optical receiver (7-i) receives one signal light (lambdai) among these two signal light (lambdai, lambdai+1) is considered here, for example. Since wavelength spacing (deltalambdai+1, i) of two signal light is smaller than the minimum permission wavelength spacing (deltalambda0) of an optical spectral separation means (5), a part of another signal light (lambdai+1) is inputted into a polarization separation means (6-i) from an optical spectral separation means (5) with the signal light (lambdai) of the direction which receives. However, since the polarization direction of these two signal light (lambdai, lambdai+1) is in abbreviation orthogonality relation, another signal light (lambdai+1) is removed by separating and taking out only the light of a component parallel to the signal light (lambdai) of the direction which receives with a polarization separation means (6-i). Therefore, only the signal light (lambdai) of the direction which receives reaches an optical receiver (7-i), and becomes receivable without the effect of crosstalk.
[0010] Moreover, if the case where an optical receiver (7-i) receives signal light (lambdai), for example following on an operation of invention of the 1st of above-mentioned this application is considered according to invention of the 2nd of this application Since light other than signal light (lambdai) is decreasing the signal light inputted into a polarization separation means (6-i) with the optical spectral separation means (5) By controlling to make output light of a polarization separation means (6-i) into max, only a component with the parallel polarization direction is automatically divided into signal light (lambdai), and an operation of invention of the 1st of above-mentioned this application is brought about.

[Translation done.]

EXAMPLE

[Example] The example of invention of the 1st of this application is explained using drawing 1 . an optical transmitter (1-1, 1-2, 1-3, --) -- for example, it is constituted by the laser diode by which direct modulation was carried out or a laser diode, the external modulator, etc., and the signal light (lambda1, lambda2, lambda3, --) modulated independently, respectively is outputted. The subscript of the wavelength of signal light shall be assigned from a short wavelength side here (lambda1<lambda2<lambda3<--). each signal light should pass a polarization adjustment means (2-1, 2-2, 2-3, --) -- it is multiplexed with an optical multiplexing means (3), and a light wave length multiple signal is formed. A polarization adjustment means (2-1, 2-2, 2-3, --) consists of a quarter-wave length plate and 1/2 wavelength plate. Have the work which changes the light of the polarization of arbitration into the linearly polarized wave of the direction of arbitration, and the polarization direction of the wavelength group (lambda 1, lambda3 --) of an odd number is [a subscript] parallel. It is adjusted so that the polarization direction of the wavelength group (lambda 2, lambda4 --) of an even number may become parallel, and it is adjusted so that the polarization direction may intersect perpendicularly by those wavelength between groups. Moreover, an optical multiplexing means is constituted by polarization composition machines, such as a polarization beam splitter, a wavelength multiplexing coupler, or the star coupler. A light wave length multiple signal inputs an optical transmission line (4) (for example, optical fiber) into an optical spectral separation means (5) after transmission. An optical spectral separation means (5) is constituted by for example, a wavelength multiplexing coupler, a diffraction grating, or prism, for every wavelength, divides the inputted light wave length multiple signal separately, and outputs it. (A crosstalk component is explained later.)
Or a configuration as shows an optical spectral separation means (5) to drawing 4 is also considered. The signal light (lambda1, lambda2, lambda3, --) transmitted in drawing 4 is distributed to an optical filter (12-1, 12-2, 12-3, --) by the star coupler (11). An optical filter (12-1, 12-2, 12-3, --) is an optical band pass filter of a dielectric multilayers mold or Fabry-Perot, and has a wavelength selection-transparency property centering on a certain main wavelength. Or it is also possible to substitute the component which has a steep gain property near a certain specific wavelength. For example, as for the signal light (lambda1, lambda2, lambda3, --) inputted into the optical filter (12-1), only signal light (lambda 1) is outputted. (A crosstalk component is explained later.)
Or a configuration as shows a spectral separation means (5) to drawing 5 is also considered. The signal light (lambda1, lambda2, lambda3, --) transmitted in drawing 5 is distributed to a main wavelength adjustable optical filter (13-1, 13-2, 13-3, --) by the star coupler (11). For example, when the signal light (lambda1, lambda2, lambda3, --) inputted into the main wavelength adjustable optical filter (13-1) carries out adjustable [of the main wavelength], only the signal light of arbitration is outputted. (A crosstalk component is explained later.)
The signal light (lambda1, lambda2, lambda3, --) separately outputted for every wavelength from this optical spectral separation means (5) is inputted into a polarization separation means (6-1, 6-2, 6-3, --), respectively. Each polarization separation means consists of for example, a quarter-wave length plate, 1/2 wavelength plate, and a polarization beam splitter, and has the work which makes only one polarization component of the arbitration of the cross polarization

light of arbitration penetrate. The output light of each polarization separation means is inputted into an optical receiver (7-1, 7-2, 7-3, --) (for example, photodiode), and is received.
[0012] The signal light to overhear was not taken into consideration in the explanation so far. In consideration of the crosstalk at the time of spectral separation, it explains from this. When an optical spectral separation means (5) performs spectral separation, the magnitude of attenuation in the relative wavelength (deltalambda0) from the main wavelength of the light separated spectrally is set to FdB. If the oppression ratio of the crosstalk permitted on the occasion of reception is set to FdB, the minimum permission wavelength spacing in this optical spectral separation means (5) will be set to (deltalambda0). Moreover, fdB, then 0<f<F are filled in the magnitude of attenuation in relative wavelength spacing (deltalambda0/2). Furthermore, since the magnitude of attenuation of a polarization separation means generally fulfills the conditions of a permission crosstalk oppression ratio when the magnitude of attenuation in case each polarization separation means (6-1, 6-2, 6-3, --) separates one polarization component of direct polarization light is set to PdB, it becomes F<P.
[0013] Here, it transmits by setting signal light (lambda1, lambda2, lambda3, --) as wavelength spacing, such as (deltalambda0 / 2). For example, in case an optical receiver (7-3) receives signal light (lambda 3), a polarization separation means (6-3) is set up so that only a component parallel to (lambda 3) may be taken out. this time -- signal light (lambda1, lambda2, lambda4, and lambda5) -- signal light (lambda 3) -- receiving -- respectively (deltalambda0) -- (deltalambda0 / 2) -- since it has wavelength spacing, and (deltalambda0/2) (deltalambda0) inputs into a polarization separation means (6-3), after decreasing only FdBfdB, and fdB and FdB with an optical spectral separation means (5), respectively. further -- the polarization direction of signal light (lambda1, lambda2, lambda4, and lambda5) -- the polarization direction of signal light (lambda 3) -- receiving -- respectively -- parallel and a perpendicular -- since it is perpendicular and parallel, only 0dB, PdB, PdB, and 0dB are decreased with a polarization separation means (6-3), respectively. Therefore, in the input of an optical receiver (7-3), signal light (lambda 3) obtains the oppression ratio of FdB, f+PdB, f+PdB, and FdB to signal light (lambda1, lambda2, lambda4, and lambda5), respectively. Moreover, since the amount of oppression of the other signal light is more than FdB at least, it satisfies more than the amount FdB of crosstalk oppression permitted, and serves as ability ready for receiving in signal light (lambda 3).
[0014] The wavelength arrangement in the above-mentioned example is set up in the following procedures. In the minimum case, since the amount [in / in a subscript / the between groups one of odd wavelength groups (lambda 1, lambda3 --) or even wavelength groups (lambda 2, lambda4 --)] of crosstalk is determined by the oppression ratio of an optical spectral separation means, the between-groups wavelength spacing becomes equal to the minimum permission wavelength spacing (deltalambda0) of an optical spectral separation means. wavelength spacing (deltalambda) of the signal which adjoins on the other hand since the amount of crosstalk of a signal light (for example, lambda2 and lambda3) different between groups is determined by the oppression ratio in a polarization separation means -- 0 -- < (deltalambda) -- < (deltalambda0) -- it can set up freely in between. However, it is more desirable to obtain a certain amount of oppression with the optical spectral separation means, if control of a polarization separation means is taken into consideration (the direction which enlarges the optical power difference of the signal to receive and the signal which is not received). it is based also on the point and practical -- etc. -- considering the case of wavelength spacing, each wavelength spacing (deltalambda) of an adjoining signal light will be set as (deltalambda0 / 2) of the one half of between-groups wavelength spacing (deltalambda0) so that wavelength spacing of a comrade between groups may be first set as (deltalambda0) and then it may be arranged at intervals of wavelength [light / all / signal] in the minimum case.
[0015] Since wavelength spacing is required also of min to perform same transmission by the conventional wavelength multiplex transmission system (deltalambda0), wavelength spacing is reduced by half by this invention.
[0016] Moreover, in implementation of invention of the 1st of this application, there is no need that an optical transmitter (1-1, 1-2, 1-3, --) and an optical receiver (7-1, 7-2, 7-3, --) are the

same numbers, and the example from which those numbers differ is also considered. The extreme example is the case where the number of receivers as shown in drawing 6 is one. In this example, spectral separation is performed with a wavelength adjustable optical filter (13-1), and it becomes ability ready for receiving about the signal light of arbitration with one receiver (7-1) among all signal light (lambda1, lambda2, lambda3, --). One application of this example is shown in drawing 7 . This application prepares n the sending stations (51) and receiving stations (52) in drawing 6 , and connects them by the nxn star coupler (53).

[0017] Moreover, one example of invention of the 2nd of this application is explained using drawing 3 . Among drawing, the thing of the same reference number as the 1st example expresses the same component, and has the same property. Moreover, drawing 8 is the configuration of the control circuit of the polarization separation means (6-3) in this example. Since the basic configuration of each polarization separation means (6-1, 6-2, 6-3, --) is the same, the following explains in the control circuit of a polarization separation means (6-3). A polarization separation means (6-3) is classified into the polarization control section (9-3) which consists of for example, a quarter-wave length plate and 1/2 wavelength plate, and the polarization separation section (10-3) which consists of for example, polarization beam splitters, is the whole and serves to make only one polarization component of the arbitration of the cross polarization light of arbitration penetrate. A negative feedback means (8-3) inputs the information about the power of the output light from a polarization separation means (6-3) from an optical receiver (7-3) in the form of an average current and electrical signals, such as instantaneous-carrying-current amplitude value, the polarization direction is rotated by the polarization control section (9-3) based on the electrical signal, and a negative feedback control is performed so that the power of the output light from the polarization separation section (10-3) may serve as maximum.

[0018] The case where an optical receiver (7-3) receives signal light (lambda 3) like one example of invention of the 1st of above-mentioned this application is considered here. As for signal light (lambda1, lambda2, lambda4, and lambda5) other than signal light (lambda 3), the light inputted into a polarization separation means (6-3) is decreasing only FdB, fdB, and fdB and FdB with the optical spectral separation means (5), respectively. this time -- the polarization direction of signal light (lambda1, lambda2, lambda4, and lambda5) -- the polarization direction of signal light (lambda 3) -- receiving -- respectively -- parallel and a perpendicular -- since it is perpendicular and parallel, in the polarization direction where the input light of a polarization separation means (6-3) is parallel to signal light (lambda 3), optical power serves as max. Since a negative feedback means (8-3) controls the polarization separation section (9-3) to make average power of the output light of a polarization separation means (6-3) into max, only a component with the parallel polarization direction is automatically outputted to signal light (lambda 3) from the polarization separation section (10-3). At this time, only 0dB, PdB, PdB, and 0dB (lambda1, lambda2, lambda4, and lambda5) of signal light are decreased by the polarization separation section (10-3), respectively. Therefore, in the input of an optical receiver (7-3), signal light (lambda 3) obtains the oppression ratio of FdB, f+PdB, f+PdB, and FdB to signal light (lambda1, lambda2, lambda4, and lambda5), respectively. Moreover, since the amount of oppression of the other signal light is more than FdB at least, it satisfies the amount FdB of crosstalk oppression permitted, and serves as ability ready for receiving in signal light (lambda 3).

[0019] Various deformation gestalten of a series of examples described above in operation of this invention are possible. For example, although the rotation phase plate was used as a means to control polarization, in a series of above-mentioned examples, the same effectiveness is acquired also with a rotation mold fiber coil or a rotation mold fiber crank, and the polarization control by Faraday rotator, a pressurization fiber, an electro-optics crystal, etc. may be used. Moreover, as a polarization composition machine or a polarization eliminator, the polarization eliminator by the prism using a birefringence and the polarization eliminator which fused the polarization maintenance fiber may be used also except a polarization beam splitter. Moreover, the optical direct junction transmission line which consists of an optical fiber and an optical amplifier as an optical transmission line may be used, and the wavelength dependency of the gain

of an optical amplifier is large, and it is effective especially when the transmission band of a transmission line is restricted.

[Translation done.]

* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The basic configuration of the 1st of invention of this application, and the configuration of one example.
[Drawing 2] The spectrum in which the principle of invention of the 1st of this application is shown.
[Drawing 3] The basic configuration of the 2nd of invention of this application, and the configuration of one example.
[Drawing 4] Another example 1 of a configuration of the optical spectral separation means in drawing 1 .
[Drawing 5] Another example 2 of a configuration of the optical spectral separation means in drawing 1 .
[Drawing 6] The configuration of the 1st of another example of invention of this application.
[Drawing 7] The application of another example of invention of the 1st of this application.
[Drawing 8] The configuration of the control circuit of the polarization separation means in drawing 3 .
[Drawing 9] The conventional example of a light wave length multiplex transmission system.
[Description of Notations]
1-1, 1-2, 1-3 -- : Optical transmitter
2-1, 2-2, 2-3 -- : Polarization control means
3 : Optical Multiplexing Means
4 : Optical Transmission Line
5 : Optical Spectral Separation Means in Wavelength Field
6-1, 6-2, 6-3 -- : Polarization separation means
7-1, 7-2, 7-3 -- : Optical receiver
8-1, 8-2, 8-3 -- : Negative feedback means
9-1, 9-2, 9-3 -- : Polarization control section
10-1, 10-2, 10-3 -- : Polarization separation section
11 : Star Coupler
12-1, 12-2, 12-3 -- : Optical filter
13-1, 13-2, 13-3 -- : Main wavelength adjustable optical filter
51 : Sending Station
52 : Receiving Station
53 : Nxn Star Coupler
lambda1, lambda2, lambda3 -- : Wavelength of signal light (lambda1<lambda2<lambda3<--)

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
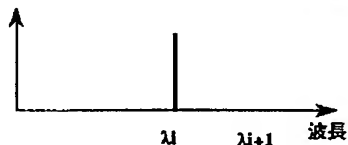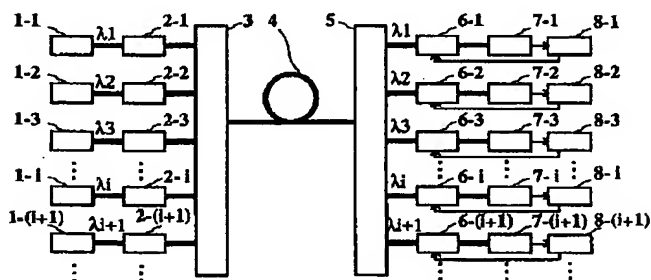3.In the drawings, any words are not translated.
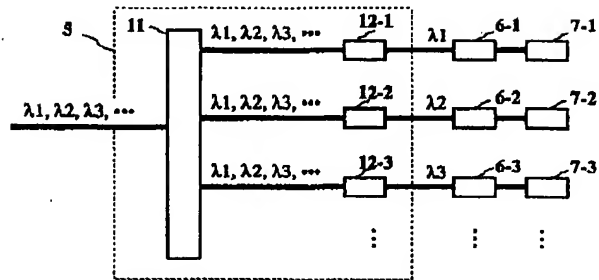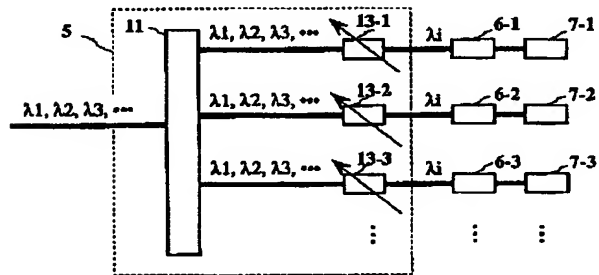
DRAWINGS

[Drawing 1]
図1
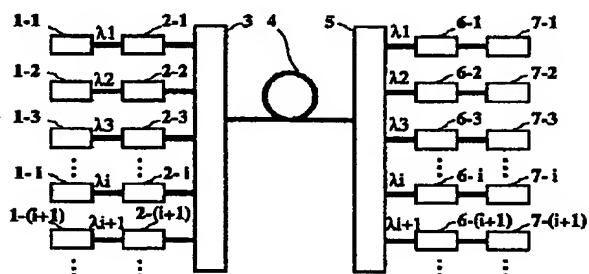
[Drawing 2]
図2
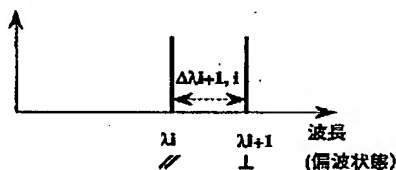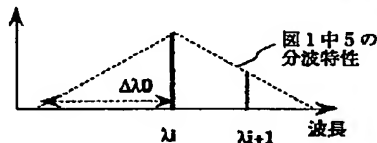
[Drawing 3]
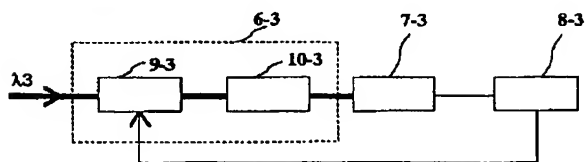図3

[Drawing 4]
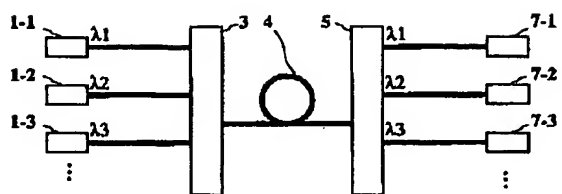
図4

[Drawing 5]

図5

[Drawing 6]

図6
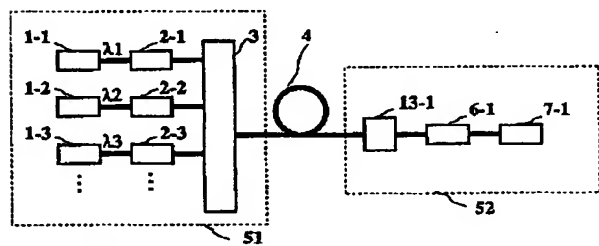
[Drawing 7]

図7
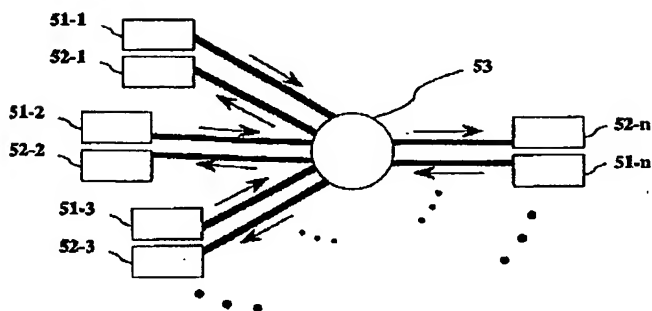
[Drawing 8]

図8

[Drawing 9]

図 9

[Translation done.]

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HO4J	14/00				
	14/04				
	14/06				
				HO4B　9/00　　　　　F	

審査請求　未請求　請求項の数2　OL　（全 6 頁）

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(54)【発明の名称】　光波長多重伝送方式

(57)【要約】

【目的】　本発明は光波長多重伝送方式に関して、異なる波長の信号光間における漏話を抑制し、かつ、波長間隔を狭めることが可能な方式を提供することにある。

【構成】　光送信器(1-1,1-2,…)と光合波手段(3)間に偏光制御手段(2-1,2-2,…)を、波長領域における光分波手段(5)と光受信器(7-1,7-2,…)間に偏光分離手段(6-1,6-2,…)をそれぞれ設け、前記光送信器の出力光間の波長間隔を、漏話を無視できる抑圧比が前記光分波手段により得られる最小の波長間隔よりも小さく設定し、かつ、それらの隣りあう波長の出力光の偏光方向を前記偏光制御手段によって略直交させる。

【効果】　本発明により信号光間の漏話を抑制したままで波長間隔を狭めることが可能となり、光波長多重伝送方式の高密度化に有効である。

図1

1
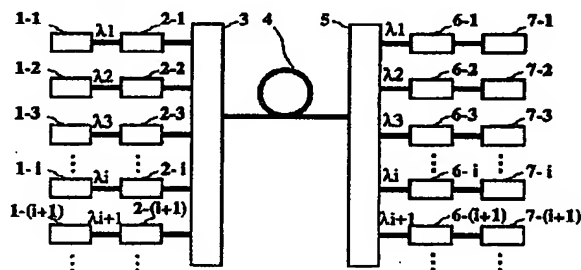
【特許請求の範囲】

【請求項1】互いに波長の異なる搬送波を用いて信号を送信する少なくとも二つ以上の光送信器と、

上記光送信器の各出力光の偏光方向を制御して出力する少なくとも二つ以上の偏光制御手段と、

上記偏光制御手段の出力光を合波する光合波手段と、

上記光合波手段の出力光を伝送する光伝送路と、

上記伝送路により伝送された信号光を波長領域において分波する光分波手段と、　上記光分波手段の分波出力光の一方向の偏光成分のみを出力する少なくとも一つ以上の偏光分離手段と、

上記偏光分離手段の出力光を受信する少なくとも一つ以上の光受信器とを備えた光波長多重伝送方式において、前記光送信器中の少なくとも一組の二つの光送信器間の波長間隔を、光信号を受信する際に漏話の影響を無視するのに必要な抑圧比を前記光分波手段において得るのに必要な最小の許容波長間隔よりも小さく設定し、

かつ、それらの組の二つの光送信器の出力光の偏光方向を前記偏光制御手段によって略直交させることを特徴とする光波長多重伝送方式。

【請求項2】前記偏光分離手段の出力光のパワーを最大にするように前記偏光分離手段を制御する負帰還手段を備えることを特徴とする請求項1に記載の光波長多重伝送方式。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は複数の波長の光信号を多重化して伝送する光波長多重伝送方式に関する。

【0002】

【従来の技術】図9は一般的な光波長多重伝送の構成図である。光送信器(1−1,1−2,1−3,…)から出力されたそれぞれ発光波長の異なる光信号(λ_1,λ_2,λ_3,…)は光カプラ等の光合波手段(3)によって合波され、光波長多重信号光を形成する。光波長多重信号光は光伝送路(4)を伝送した後に、波長領域における光分波手段(5)により各波長毎に分波されて光受信器(7−1,7−2,7−3,…)に入力される。

【0003】このような光波長多重伝送方式では、ある信号光を受信する際、波長領域における光分波手段(5)によって受信する信号光の他の全信号光を除去する必要がある。しかし、受信する信号と、その受信する信号光と隣接する波長の信号光の波長間隔が小さ過ぎる場合には、光分波手段(5)ではその隣接する波長の信号光を除去しきれないために、受信信号光と同時に、受信信号光に隣接する波長の信号光のパワーの一部も光受信器(7−1,7−2,7−3,…)に入力し、信号間の漏話を引き起こす。

【0004】こうした信号間の漏話を防ぐために、一般に波長多重伝送方式では、各光送信器が出力する信号光間の波長間隔を十分に拡げて、信号光を受信する際に漏話の影響を無視できるのに十分な抑圧比を、光分波手段

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において得ている。こうした手法に関しては、例えば光分波手段にファブリ＝ペロ共振器型のフィルタを用いた場合について、ハンブレット他、アイ・トリプル・イー・ジャーナル・オン・セレクテッド・エアリアス・イン・コミュニケイションズ第8巻、第6号、第1095−1107頁、1990年（P. A. Humblet et al., IEEE Journal on Selected Areas in Commuincations, Vol. 8, No. 6, pp. 1095-1107, 1990）にて詳しく議論されている。

【0005】

【発明が解決しようとする課題】しかしながら上記の従来の方法では、信号光間の波長間隔を、信号光を受信する際に漏話の影響を無視するのに十分な抑圧比を前記光分波手段において得るのに必要な最小の許容波長間隔よりも、狭めることができず、信号光を高密度に多重して伝送容量を大容量化する際に障害となってしまう欠点があった。

【0006】本発明の目的は、前記問題点を解決し、受信器における漏話の影響を抑制し、かつ、波長間隔を小さくすることが可能である光波長多重伝送方式を提供することにある。

【0007】

【課題を解決するための手段】図1は本願の第1の発明の基本構成図である。上記目的を達成するために本願の第1の発明が提供する構成は、互いに波長（λ_1,λ_2,λ_3,…）の異なる搬送波を用いて信号を送信する少なくとも二つ以上の光送信器(1−1,1−2,1−3,…)と、その光送信器の各出力光の偏光方向を制御して出力する少なくとも二つ以上の偏光制御手段(2−1,2−2,2−3,…)と、その偏光制御手段の出力光を合波する光合波手段(3)と、その光合波手段の出力光を伝送する光伝送路(4)と、その伝送路により伝送された光信号を波長領域において分波する光分波手段(5)と、その光分波手段の分波出力光の一方向の偏光成分のみを出力する少なくとも一つ以上の偏光分離手段(6−1,6−2,6−3,…)と、その偏光分離手段の出力光を受信する光受信器(7−1,7−2,7−3,…)とを備えた光波長多重伝送方式において、前記光送信器中の少なくとも一組の二つの光送信器の出力光（λ_i,λ_{i+1})間の波長間隔（$\Delta\lambda_{i+1,i} = \lambda_{i+1} - \lambda_i$)を、光信号を受信する際に漏話の影響を無視するのに必要な抑圧比を前記光分波手段において得るのに必要な最小の許容波長間隔（$\Delta\lambda_0$)よりも小さく設定し（$\Delta\lambda_{i+1,i} < \Delta\lambda_0$)、かつ、それらの組の二つの光送信器の出力光（$\lambda_i$,$\lambda_{i+1}$)の偏光方向を前記偏光制御手段(2−i,2−(i+1)）によって略直交させることを特徴とする。

【0008】また、図3は本願の第2の発明の基本構成図である。上記の目的を達成するために本願の第2の発明が提供する構成は、前記本願の第1の発明が提供する構成に加え、かつ、前記偏光分離手段(6−1,6−2,6−3,…)の出力光のパワーを最大とするようにその偏光分離手段

（3）

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を制御をする負帰還手段(8-1,8-2,8-3,…)を備えること
を特徴とする。

【0009】
【作用】図2は本願の第1の発明の原理図である。本願
の第1の発明によれば、光分波手段(5)が定める最小許
容波長間隔($\Delta\lambda_0$)に対し、小さい波長間隔($\Delta\lambda_{i,i+1}$)
で設定された二つの信号光(λ_i,λ_{i+1})は、偏光制御手
段(2-i,2-(i+1))により偏光方向が略直交するように偏
光制御されてから送信される。ここで例えば、この二つ
の信号光(λ_i,λ_{i+1})のうち、一方の信号光(λ_i)を光受
信器(7-i)で受信する場合を考える。二つの信号光の波
長間隔($\Delta\lambda_{i,i+1}$)は光分波手段(5)の最小許容波長間隔
($\Delta\lambda_0$)よりも小さいので、受信する方の信号光(λ_i)と
共にもう一方の信号光(λ_{i+1})の一部が、光分波手段(5)
から偏光分離手段(6-i)に入力される。しかし、この二
つの信号光(λ_i,λ_{i+1})の偏光方向は略直交関係にある
ので、偏光分離手段(6-i)により受信する方の信号光(λ_i)に平行な成分の光のみを分離して取り出すことによ
り、もう一方の信号光(λ_{i+1})は除去される。よって、
受信する方の信号光(λ_i)のみが光受信器(7-i)に達し、
漏話の影響なしに受信が可能となる。

【0010】また、本願の第2の発明によれば、例えば
上記の本願の第1の発明の作用に引き続き信号光(λ_i)
を光受信器(7-i)で受信する場合を考えると、偏光分離
手段(6-i)に入力する信号光は光分波手段(5)により信号
光(λ_i)以外の光は減衰されているので、偏光分離手段
(6-i)の出力光を最大にするように制御を行うことによ
り、自動的に信号光(λ_i)に偏光方向が平行な成分のみ
が分離され、上記の本願の第1の発明の作用をもたら
す。

【0011】
【実施例】本願の第1の発明の実施例を図1を用いて説
明する。光送信器(1-1,1-2,1-3,…)は例えば直接変調
されたレーザダイオード、あるいはレーザダイオードと外
部変調器等により構成され、それぞれ独立に変調された
信号光($\lambda_1,\lambda_2,\lambda_3,…$)を出力する。ここで信号光の波
長の添字は短波長側より割り当てる($\lambda_1<\lambda_2<\lambda_3<$
…)ものとする。各信号光は、偏光調整手段(2-1,2-2,2-
3,…)を経て、光合波手段(3)で合波されて光波長多重信
号を形成する。偏光調整手段(2-1,2-2,2-3,…)は1/4波
長板と1/2波長板から構成され、任意の偏波の光を任意
の方向の直線偏波に変換する働きを有し、添字が奇数番
号の波長群($\lambda_1,\lambda_3,…$)の偏光方向が平行、偶数番号の
波長群($\lambda_2,\lambda_4,…$)の偏光方向が平行となるように調整
され、かつ、それらの波長群間で偏光方向が直交するよ
うに調整されている。また、光合波手段は、偏波ビーム
スプリッタなどの偏波合成器、あるいは波長多重カブ
ラ、あるいはスターカブラ等により構成される。光波長
多重信号は光伝送路(4)（例えば光ファイバ）を伝送
後、光分波手段(5)に入力する。光分波手段(5)は例えば

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波長多重カブラ、あるいは回折格子、あるいはプリズム
等により構成され、入力された光波長多重信号をそれぞ
れの波長毎に別々に分けて出力する。（漏話成分につい
ては後で説明する。）
あるいは、光分波手段(5)は図4に示すような構成も考
えられる。図4にて伝送された信号光($\lambda_1,\lambda_2,\lambda_3,…$)
はスターカブラ(11)により光フィルタ(12-1,12-2,12-3,
…)に分配される。光フィルタ(12-1,12-2,12-3,…)は誘
電体多層膜型あるいはファブリ＝ペロ型の光バンドパス
フィルタであり、ある中心波長を中心とした波長選択的
透過特性を有する。あるいは、ある特定波長の近傍にて
急峻な利得特性を持つ素子で代用することも可能であ
る。例えば光フィルタ(12-1)に入力した信号光($\lambda_1,
\lambda_2,\lambda_3,…$)は信号光($\lambda_1$)のみが出力される。（漏話成
分については後で説明する。）
あるいは、分波手段(5)は図5に示すような構成も考え
られる。図5にて伝送された信号光($\lambda_1,\lambda_2,\lambda_3,…$)は
スターカブラ(11)により中心波長可変の光フィルタ(13-
1,13-2,13-3,…)に分配される。例えば中心波長可変の
光フィルタ(13-1)に入力した信号光($\lambda_1,\lambda_2,\lambda_3,…$)は
中心波長を可変することにより任意の信号光のみが出力
される。（漏話成分については後で説明する。）
この光分波手段(5)から波長毎に別々に出力された信号
光($\lambda_1,\lambda_2,\lambda_3,…$)はそれぞれ偏光分離手段(6-1,6-2,6
-3,…)に入力する。各偏光分離手段は例えば1/4波長板
と1/2波長板と、偏波ビームスプリッタとから構成さ
れ、任意の直交偏波光の任意の一方の偏光成分のみを透
過させる働きを有する。各偏光分離手段の出力光は光受
信器(7-1,7-2,7-3,…)（例えばフォトダイオード）に入
力され受信される。

【0012】ここまでの説明では漏話する信号光を考慮
しなかった。これより分波時における漏話を考慮して説
明をする。光分波手段(5)が分波を実行する時、分波さ
れた光の中心波長からの相対波長($\Delta\lambda_0$)における減衰
量をF dBとする。受信に際して許容される漏話の抑圧比
をF dBとすると、この光分波手段(5)における最小許容
波長間隔は($\Delta\lambda_0$)となる。また、相対波長間隔($\Delta\lambda_0
/2$)における減衰量をf dBとすれば$0<f<F$が満た
される。さらに、各偏光分離手段(6-1,6-2,6-3,…)が直
行偏波光の一方の偏光成分を分離する時の減衰量をP dB
とした時、一般に偏光分離手段の減衰量は許容漏話抑圧
比の条件を満たすので、$F<P$となる。
【0013】ここで、信号光($\lambda_1,\lambda_2,\lambda_3,…$)を($\Delta\lambda_0
/2$)の等波長間隔に設定して伝送を行う。例えば信号
光(λ_3)を光受信器(7-3)で受信する際には、偏光分離手
段(6-3)を(λ_3)に平行な成分のみを取り出すように設定
する。この時、信号光($\lambda_1,\lambda_2,\lambda_4,$及び$\lambda_5$)は信号光
(λ_3)に対してそれぞれ($\Delta\lambda_0$),($\Delta\lambda_0/2$),($\Delta\lambda_0/
2$)及び($\Delta\lambda_0$)の波長間隔を持つので、光分波手段(5)
によってそれぞれF dB, f dB, f dB及びF dBだけ減衰さ

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れてから偏光分離手段(6-3)に入力する。さらに信号光(λ₁,λ₂,λ₄及びλ₅)の偏光方向は信号光(λ₃)の偏光方向に対してそれぞれ平行、垂直、垂直、及び平行であるので、偏光分離手段(6-3)によりそれぞれ0dB，PdB，PdB及び0dBだけ減衰する。よって、光受信器(7-3)の入力において信号光(λ₃)は信号光(λ₁,λ₂,λ₄及びλ₅)に対してそれぞれFdB，f+PdB，f+PdB及びFdBの抑圧比を得る。また、それ以外の信号光の抑圧量は少なくともFdB以上であるので、許容される漏話抑圧量FdB以上を満足して信号光(λ₃)を受信可能となる。

【0014】上記実施例における波長配置は以下の手順で設定されている。添字が奇数の波長群(λ₁,λ₃…)、あるいは偶数の波長群(λ₂,λ₄…)の同群間における漏話量は光分波手段の抑圧比によって決定されるので、その同群間波長間隔は最小の場合で光分波手段の最小許容波長間隔(Δλ₀)に等しくなる。一方、異群間の信号光(例えばλ₂とλ₃)の漏話量は偏光分離手段における抑圧比で決定されるので、隣接する信号の波長間隔(Δλ)は0<(Δλ)<(Δλ₀)の間で自由に設定が可能である。ただし、偏光分離手段の制御を考慮すると、光分波手段によりある程度の抑圧を得ておく方が（受信する信号と受信されない信号の光パワー差を大きくしておく方が）望ましい。その点も踏まえて、実用的な等波長間隔の場合を考えると、最小の場合で、まず同群間同志の波長間隔を(Δλ₀)に設定し、次に全信号光が等波長間隔で配置されるように、隣接する信号の各波長間隔(Δλ)を同群間波長間隔(Δλ₀)の半分の(Δλ₀／2)に設定することになる。

【0015】同様の伝送を従来の波長多重伝送システムで実行する場合には波長間隔は最小でも(Δλ₀)必要であるので、本発明により波長間隔は半減される。

【0016】また、本願の第1の発明の実施においては光送信器(1-1,1-2,1-3,…)と光受信器(7-1,7-2,7-3,…)が同数である必要性はなく、それらの数が異なる実施例も考えられる。その極端な例は図6に示すような受信器が1つの場合である。この実施例においては分波を波長可変の光フィルタ(13-1)により実行し、1つの受信器(7-1)で全信号光(λ₁,λ₂,λ₃,…)のうち任意の信号光を受信可能となる。この実施例の一応用例を図7に示す。この応用例は、図6中の送信局(51)と受信局(52)をn局設け、n×nスターカプラ(53)で接続したものである。

【0017】また、本願の第2の発明の一実施例を図3を用いて説明する。図中、第1の実施例と同じ参照番号のものは同じ構成要素を表し、同じ特性を持つ。また、図8は本実施例における偏光分離手段(6-3)の制御回路の構成である。各偏光分離手段(6-1,6-2,6-3,…)の基本構成は同じであるので、以下は偏光分離手段(6-3)の制御回路において説明をする。偏光分離手段(6-3)は例えば1/4波長板と1/2波長板から構成される偏光制御部(9-3)、及び例えば偏波ビームスプリッタから構成される偏

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光分離部(10-3)に区分され、全体で、任意の直交偏波光の任意の一方の偏光成分のみを透過させる働きをする。負帰還手段(8-3)は偏光分離手段(6-3)からの出力光のパワーに関する情報を光受信器(7-3)から平均電流や、瞬時電流振幅値等の電気信号の形で入力し、その電気信号に基づいて偏光制御部(9-3)で偏光方向を回転させて、偏光分離部(10-3)からの出力光のパワーが最大値となるように負帰還制御を行う。

【0018】ここで上記の本願の第1の発明の一実施例と同様に信号光(λ₃)を光受信器(7-3)で受信する場合を考える。偏光分離手段(6-3)に入力する光は光分波手段(5)にて信号光(λ₃)以外の信号光(λ₁,λ₂,λ₄及びλ₅)はそれぞれFdB，fdB，fdB及びFdBだけ減衰されている。この時、信号光(λ₁,λ₂,λ₄及びλ₅)の偏光方向は信号光(λ₃)の偏光方向に対してそれぞれ平行、垂直、垂直、及び平行であるので、偏光分離手段(6-3)の入力光は信号光(λ₃)に平行な偏光方向において光パワーが最大となる。負帰還手段(8-3)は偏光分離手段(6-3)の出力光の平均パワーを最大とするように偏光分離部(9-3)の制御を行うので、自動的に信号光(λ₃)に偏光方向が平行な成分のみが偏光分離部(10-3)から出力される。この時、信号光(λ₁,λ₂,λ₄及びλ₅)は偏光分離部(10-3)によりそれぞれ0dB，PdB，PdB及び0dBだけ減衰される。よって、光受信器(7-3)の入力において信号光(λ₃)は信号光(λ₁,λ₂,λ₄及びλ₅)に対してそれぞれFdB，f+PdB，f+PdB及びFdBの抑圧比を得る。また、それ以外の信号光の抑圧量は少なくともFdB以上であるので、許容される漏話抑圧量FdBを満足して信号光(λ₃)を受信可能となる。

【0019】本発明の実施に当たっては、上記した一連の実施例の様々な変形形態が可能である。例えば、上記一連の実施例では、偏光を制御する手段として回転位相板を用いたが、回転型ファイバコイルや回転型ファイバクランクでも同様の効果が得られ、また、ファラデー回転子や加圧ファイバ、電気光学結晶等による偏光制御を用いてもよい。また、偏波合成器や偏光分離器としては偏波ビームスプリッタ以外でも、複屈折を利用したプリズムによる偏光分離器や、偏波保持ファイバを溶融した偏光分離器を用いても良い。また、光伝送路として光ファイバと光増幅器から構成される光直接中継伝送路を用いてもよく、光増幅器の利得の波長依存性が大きく、伝送路の伝送帯域が制限されている場合には特に有効である。

【0020】

【発明の効果】以上に説明したように本発明によれば、漏話を抑制したままで波長間隔を狭めることが可能となるので、信号を高密度に多重して光波長多重伝送する場合に有効であり、又、伝送帯域の狭い伝送路を用いて光波長多重伝送する場合にも有効である。

【0021】

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【図面の簡単な説明】
【図1】本願の第1の発明の基本構成、及び一実施例の構成。
【図2】本願の第1の発明の原理を示すスペクトル。
【図3】本願の第2の発明の基本構成、及び一実施例の構成。
【図4】図1中の光分波手段の別の構成例1。
【図5】図1中の光分波手段の別の構成例2。
【図6】本願の第1の発明の別の実施例の構成。
【図7】本願の第1の発明の別の実施例の応用例。
【図8】図3中の偏光分離手段の制御回路の構成。
【図9】従来の光波長多重伝送方式例。
【符号の説明】
1−1,1−2,1−3,… : 光送信器
2−1,2−2,2−3,… : 偏光制御手段
3 : 光合波手段

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＊4 : 光伝送路
5 : 波長領域における光分波手段
6−1,6−2,6−3,… : 偏光分離手段
7−1,7−2,7−3,… : 光受信器
8−1,8−2,8−3,… : 負帰還手段
9−1,9−2,9−3,… : 偏光制御部
10−1,10−2,10−3,… : 偏光分離部
11 : スターカプラ
12−1,12−2,12−3,… : 光フィルタ
13−1,13−2,13−3,… : 中心波長可変の光フィルタ
51 : 送信局
52 : 受信局
53 : n×nスターカプラ
$\lambda_1, \lambda_2, \lambda_3, \cdots$: 信号光の波長 （$\lambda_1 < \lambda_2 < \lambda_3 <$ …）

＊

【図1】

【図2】

【図3】

【図4】

【図5】

図5

【図6】

図6

【図7】

図7

【図8】

図8

【図9】
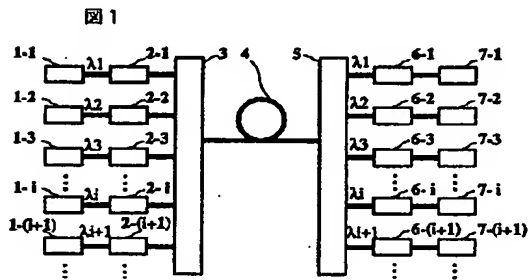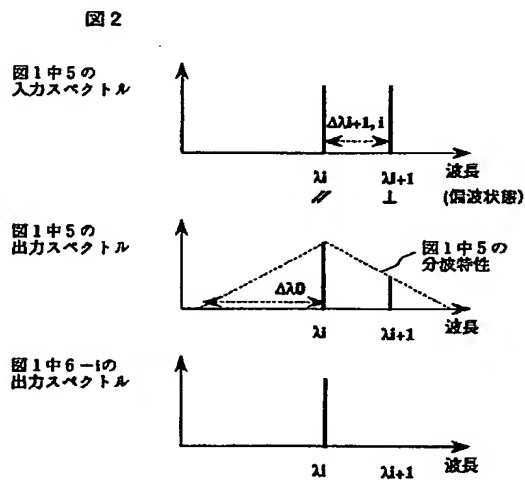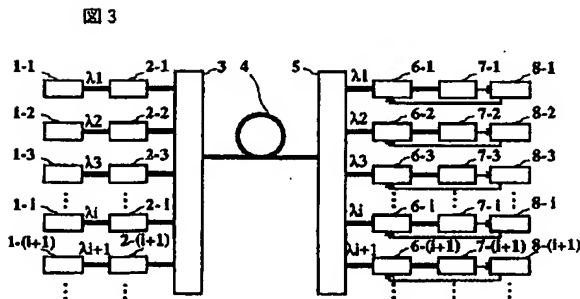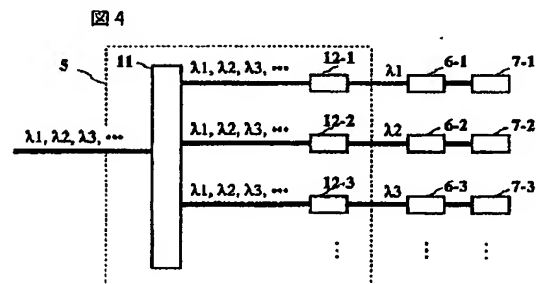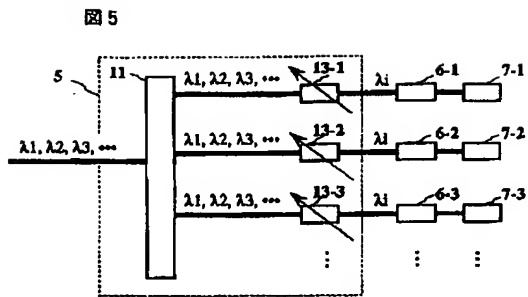
図9

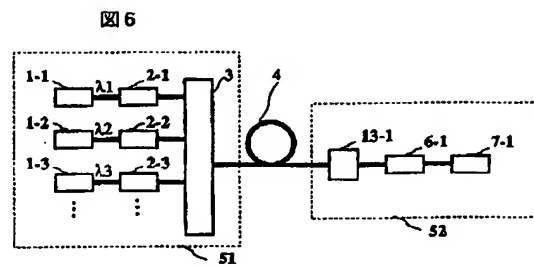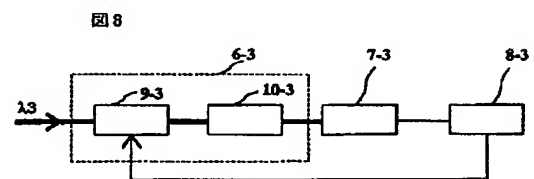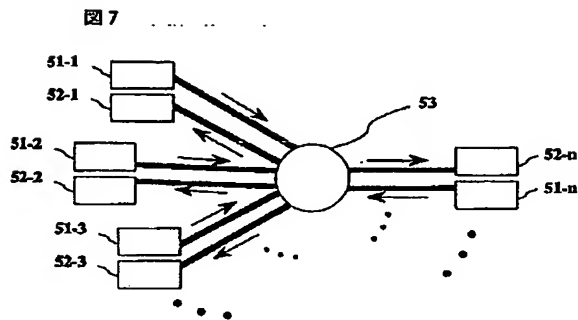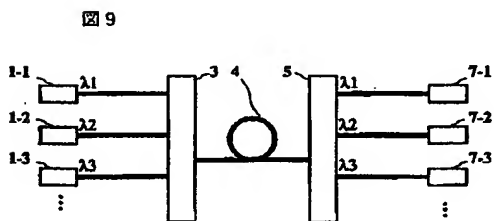
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